

(NASA-TM-85019) NETWORKING DEC AND IBM
COMPUTERS (NASA) 16 p HC A02/MF A01

N83-27633

CSCL 09B

Unclas
G3/62 12147



Technical Memorandum 85019

NETWORKING DEC AND IBM COMPUTERS

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MAY 1983

National Aeronautics and
Space Administration

Goddard Space Flight Center
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SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET

1. Report No. TM 85019	2. Government Accession No.	3. Recipient's Catalog No. N83-27633	
4. Title and Subtitle Networking DEC and IBM Computers		5. Report Date May 1983	
		6. Performing Organization Code	
7. Author(s) W. H. Mish		8. Performing Organization Report No.	
9. Performing Organization Name and Address NASA/GSFC Laboratory for Extraterrestrial Physics Information Analysis & Display Office, Code 694 Greenbelt, MD 20771		10. Work Unit No.	
		11. Contract or Grant No.	
		13. Type of Report and Period Covered Technical Memorandum	
12. Sponsoring Agency Name and Address		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract <p style="margin-left: 40px;">This paper discusses what is currently available to allow Local Area Networking of DEC and IBM computers within the structure of the ISO-OSI Seven Layer Reference Model at a raw signaling speed of 1 Mbps or greater.</p> <p style="margin-left: 40px;">After an introduction to the ISO-OSI Reference Model and the IEEE-802 Draft Standard for Local Area Networks (LANs), there follows a detailed discussion and comparison of the what products are available from a variety of manufacturers to perform this networking task. A summary of these products is presented in Table 1 at the end of this paper.</p>			
17. Key Words (Selected by Author(s)) Networking, computers, Local Area Networking		18. Distribution Statement	
19. Security Classif. (of this report) U	20. Security Classif. (of this page) U	21. No. of Pages 14	22. Price*

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ABSTRACT

This paper discusses what is currently available to allow Local Area Networking of DEC and IBM computers within the structure of the ISO-OSI Seven Layer Reference Model at a raw signaling speed of 1 Mbps or greater.

After an introduction to the ISO-OSI Reference Model and the IEEE-802 Draft Standard for Local Area Networks (LANs), there follows a detailed discussion and comparison of the what products are available from a variety of manufacturers to perform this networking task. A summary of these products is presented in Table 1 at the end of this paper.

1.) INTRODUCTION

For the purposes of this paper a computer network is defined as a collection of autonomous computers, called hosts, that cooperate with each other to exchange information over some form of communications channel.

Computer Networks can be classified as Local Area Networks (LANs) or Long-Haul Networks. The hosts on a Local Network are generally located in a single building or campus, are connected by high-bandwidth communications, and are generally owned by a single organization. On the other hand, Long-Haul Networks typically consist of hosts that are separated by large geographical distance, use the public communication channels, and normally involve at least two organizations: the carrier, which operate the communication facility, and the users who own the hosts.

For sometime we have been researching what is required to implement a true Local Area Network (LAN) of DEC and IBM/370 computers (located less than several Kilometers apart) using the "contention" method of acquiring the communication channel (Rebibo and Miller, 1982; Berman, 1982). This LAN is to be constructed with field proven hardware/software within the structure of the International Organization for Standardization's Reference Model for Open Systems Interconnection (ISO-OSI) seven layer model. This network is not designed to be used for security or extremely high reliability applications. Eventually it is planned to provide a "gateway" to Long-Haul Networks. Most traffic over this LAN will be bulk file transfers among hosts and will require transfer rates of 1 Megabit/s or greater and Direct Memory Access (DMA) interfaces to the hosts. These high speeds are necessary as the effective point-to-point transfer rate is typically a small fraction (Berman, 1982; Wood, 1981) of the electrical signaling rate if the high level protocols are implemented in the hosts. Thus a signaling rate of 1 megabits/s may result in an effective rate of only several 100Kbps.

This paper presents a review of the current (Second Quarter CY 83) products available to perform this LAN task and discusses the strengths and weaknesses of the products available.

Before starting a comparison of LAN vendor's products, we lay the necessary groundwork by:

- a.) discussing the OSI Reference Model,
- b.) discussing the IEEE-802 LAN Standard, including the "contention" method of using the communication channel referred to as Carrier Sense Multiple Access/Collision Detect (CSMA/CD), which has implementations in both baseband (no RF carrier) and broadband (RF carrier); we only briefly touch on the "token passing" method of acquiring the communication channel also covered in the IEEE-802 Standard,
- c.) defining the terminology required to make the comparisons and finally,
- d.) presenting a detailed comparison of the different vendor's products that are available.

2.) THE ISO SEVEN LAYER MODEL

The ISO seven layer Reference Model (Tanenbaum, 1981) provides the framework for describing computer networks, both LANs and Long-Haul, and provides a uniform nomenclature. Note that it is not a standard in and of itself but helps make the standards effort manageable by providing the model (Graube, 1982). A diagram of this Model appears in Fig. 1, representing communication between two hosts.

Referring to Fig. 1, if two applications on different hosts wish to communicate, the model subdivides the communication task into layers. These layers support one another in a hierarchical fashion. Layers communicate with their peers on the other host via protocols that specify how a particular task is to be carried out. These protocols

consist of messages with specific formats and rules for exchanging the message. It is only at Layer 1 (Physical Layer) that there is an actual physical connection, all other connections are logical, shown in Fig. 1 as dotted lines.

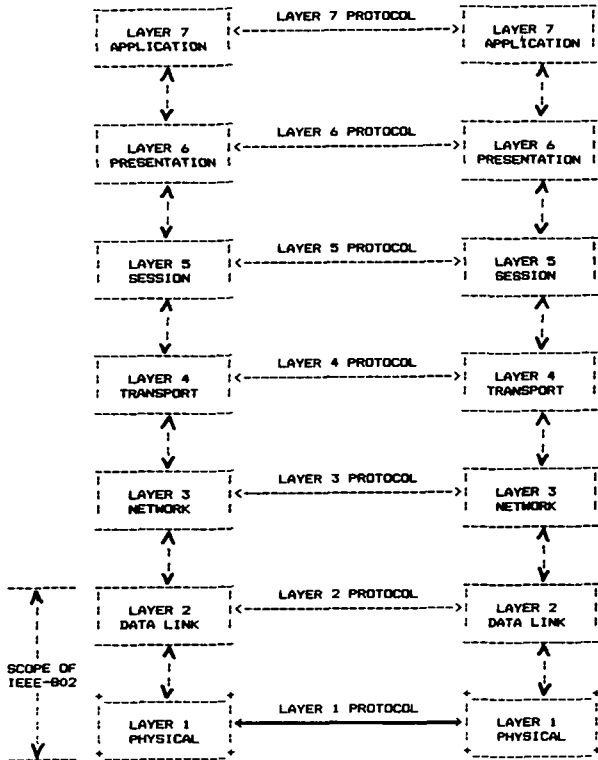


Fig. 1 ISO-OSI 7 LAYER MODEL

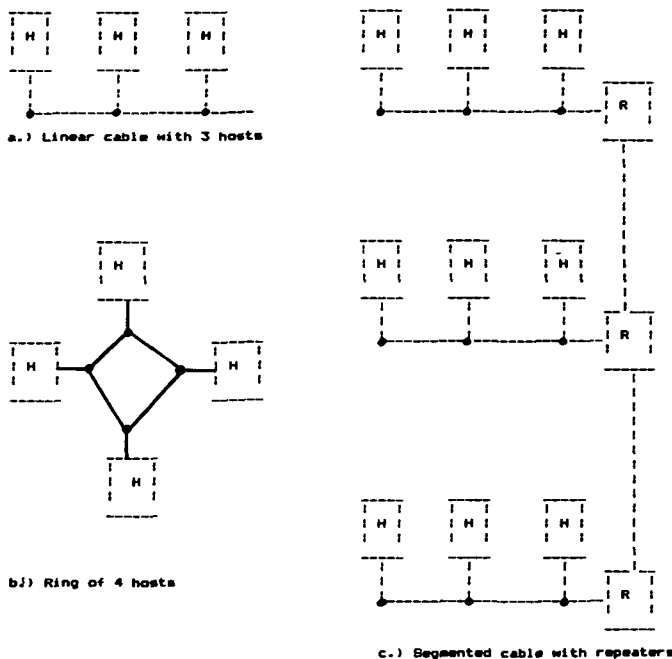


Fig. 2 LAN TOPOLOGIES

physical-layer 1

The physical layer is concerned with the transmission of a raw bit stream: how ones and zeros are represented, timings, pinouts, the other electrical, mechanical and procedural details of the hardware used for transmission.

Most LANs are connected by linear, tree-shaped, or ring shaped cable as shown in Fig. 2 (after Tanenbaum, 1981).

data link-layer 2

The data link layer converts a possible unreliable transmission channel into a reliable one. Reliability is obtained by breaking the raw bit stream into frames, each containing a checksum (CRC) for detecting errors. Three methods are in common use for delimiting frames: character count, character stuffing and bit stuffing. In the first method each frame contains a count that tells how many characters are contained in the frame. The method has the disadvantages of being sensitive to undetected transmission errors which affect the count field and of enforcing a specific character size. DEC's Digital Data Communication Message Protocol (DDCMP) is an example of a character count protocol. The character stuffing protocol terminates each frame with a special "end of frame" character. The problem here is how to handle accidental "end-of-frame" characters embedded in the data, e.g., in the middle of a floating point number. The solution is to insert an "escape" character before the accidental "end-of-frame". Accidental "escape" characters are transmitted as two consecutive "escapes". The problem with the character stuffing is that a specific character code is built into the protocol. IBM Binary Synchronous Communication (BISYNC) is an example. Modern link protocols use bit stuffing, a technique in which frames are delimited by the bit pattern: a zero, six consecutive ones, and a zero. The accidental occurrence of five consecutive ones in the data stream is handled by stuffing a zero into the data, normally done by hardware, thus preventing data from interfering with framing, but not at the expense of imposing a specific character length or code. High-Level Data Link Control (HDLC) and its many variants, e.g., SDLC, ADCCP, LAP, LAPB are examples of bit stuffing protocols.

The datalink layer is often implemented in the form of a hardware protocol chip.

network-layer 3

The network layer is primarily concerned with routing and congestion control and may be resident in a device driver.

In a Local Area Network most hosts have an interface card inserted into their backplane to control access to the network. This interface card is in turn attached to the communication channel, usually a cable (see Fig. 2). Thus, in a LAN, routing and congestion control are less prominent than in Long-Haul Networks.

transport-layer 4

The transport layer hides the details of the communications subnet (layers 1,2 & 3) from the next layer up: the Session layer. That is, the Session layer should not have to worry about the implementation details of the network. The network layer (layer 3) does not necessarily ensure that the bit stream transmitted actually reached the destination intact. For example, packets may be lost or reordered and it is the function of the transport layer to discover these types of problems and take corrective action. The transport layer may reside in the Operating System of the host or in hardware separate from the host.

session-layer 5

The session layer sets up, manages and tears down process-to-process connections, using the host-to-host service provided by the transport layer and may reside in the operating system of the hosts.

presentation-layer 6

The presentation layer performs generally useful transformations on the data to be sent/received, e.g., text compression, format conversions etc. This layer is often located in a set of library routines in the user's address space.

application-layer 7

The functions performed by the application layer are specific to the application and are not addressed in this paper.

3.) LOCAL AREA NETWORK (LAN) STANDARDS

The principal Standards body relating to LANs is the IEEE. IEEE-802 (IEEE-802 Draft B and D, 1982) will be the Standards Family used for the construction of LANs in the future. Although IEEE-802 is still in draft form a large fraction of the Standard is generally accepted throughout the industry.

IEEE-802 Standard defines a LAN Reference Model (see Fig 3), which is a layered peer-to-peer model that corresponds, but is not identical, to layers 1 and 2 of the OSI Reference Model just discussed. It defines a network capable of connecting up to 200 devices distributed along a communication medium of at least 2 Km in length at speeds of 1-20 Mbps.

Unlike the OSI Reference Model Layer 3 the LAN Reference Model has no intermediate switching/routing modes. This is because the hosts attach directly to the LAN for direct point-to-point communications.

OSI layers 1 and 2 map onto the LAN Reference Model's Logical Link Control (LLC), Media Access Control (MAC) and Physical Layers (see Fig. 3). The LLC is based on the OSI Reference Model Layer 2 (Data Link Layer), using HDLC. The MAC provides a mechanism for timesharing access to a single-media channel either by Contention or by Token Passing.

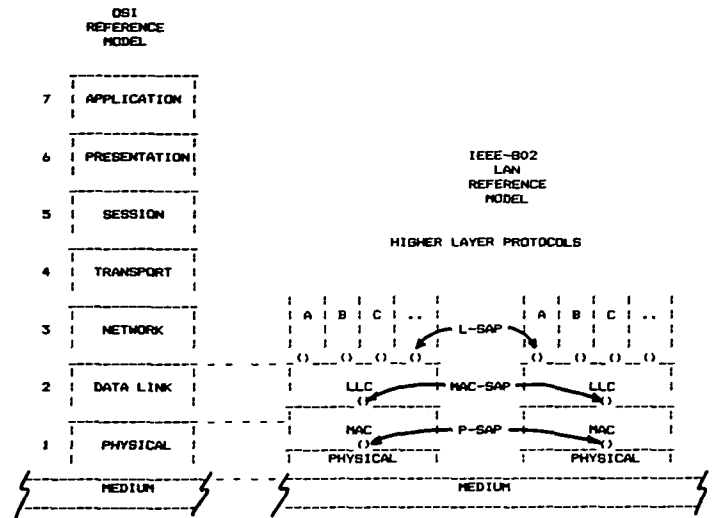


Fig. 3 LAN REFERENCE MODEL

Service Access Points (SAPs), for addressing end points, are shown in Fig. 3. To provide support for multiple higher layer client protocols (A,B,C...), LLC Service Access Points (L-SAPs) provide interface ports at the Layer 3/2 boundary for protocols A, B, and C at the Network Layer (Layer 3). A MAC-SAP provides a single interface port to a single LLC entity. Physical Service Access Points (P-SAPs) provide an interface port to a single MAC entity.

Logical Link Layer (LLC)

Connection (Virtual Circuit) service -- a logical link is established between pairs of L-SAPs prior to any exchange of user data. In the data transfer mode, frames are transmitted/delivered in sequence. Error recovery and flow control are provided.

Connectionless (Datagram) service -- frames are exchanged between LLC stations without the need for the establishment of a logical link between two L-SAPs. In LLC these frames are not acknowledged nor are there any flow control or error recovery procedures. Flow control and error recovery, in this case, would normally be handled by the Transport Layer.

The Link Layer is responsible for sending and receiving a unit of data. This consists of a simple packet structure with source, destination, type, data, and Cyclic Redundancy Check (CRC) fields. All stations are assigned 48 bit address that is unique in world. Cyclic Redundancy Check (CRC) guarantees one bit error in 10^{13} . The data field is from 46-1500 bytes in length.

Media Access Control (MAC)

Two methods of access control to the physical cable are described: (1) CSMA/CD (probabilistic method); and, (2) Token (deterministic method).

Physical Layer

Also two methods of data signaling are described: (1) Baseband (one channel via square wave signaling); for baseband operation the P-SAP is a null, as every host is connected onto one LAN; and, (2) Broadband (multiple channels via RF modulation); for broadband operation the P-SAP would be one channel assignment frequency. Most of the current broadband implementations allow for 5 P-SAPs.

3.1) CONTENTION-CSMA/CD

Briefly, the CSMA/CD media access control (MAC) mechanism is a "listen before talk" and "listen while talking" protocol. It necessarily detects collision caused by multiple hosts simultaneously starting a transmission. The collisions recovery consists of aborting the current transmission, broadcasting a noise burst to inform the other hosts of the collision, waiting a random time and trying again. Collision detection limits the geographic size of a network because the propagation delay must be short compared to the packet transmission time. A station always listens to all traffic. It receives all packets and checks destination field and CRC and only retains address matches with a good CRC. The type of service rendered can be a "datagram" service, i.e., there is no acknowledgment by the MAC and it depends on the Transport Layer to detect and correct lost or out of order packet situations or a "connection" service where the Data Link Layer is responsible for data being transmitted correctly.

3.1.1) CSMA/CD BASEBAND (DATA SIGNALING DONE WITH NO CARRIER USING COAXIAL CABLE)

The Baseband CSMA/CD adopted by IEEE-802 Standard is almost identical to the Xerox Ethernet Specification with minor changes, most of which concerned grounding. Of course Xerox, DEC and Intel adopted Ethernet as their official standard for LANs sometime ago (The Ethernet, 1982). The Ethernet specification must be licensed from Xerox at a one-time nominal fee.

ETHERNET ADVANTAGES AND DISADVANTAGES (Berman, 1982)

ETHERNET ADVANTAGES

- o well defined by standards
 - IEEE 802
 - ECMA
 - CCITT (expected soon)
- o accepted by major manufacturers
 - Xerox, Intel, DEC and many, many others
- o multiple indep. sources of interfaces
 - 3COM, Interlan, Ungermann-Bass
- o large installed base
- o easy installation
- o universal station address
- o 10 Mbps trunk base
- o very efficient under heavy load at physical level
- o relatively inexpensive physical interfaces
- o media-access control protocol to be in VLSI soon
- o "equal opportunity" protocol gives all users same response, lockouts unlikely
- o high level architecture derived by several vendors
- o network statistics readily captured

ETHERNET DISADVANTAGES

- o limited distance, 2.5 km max. between stations
- o limited total bandwidth on cable (10 Mbps)
- o single faulty transmitter can jam entire net

3.1.2) CSMA/CD BROADBAND (DATA SIGNALING BY RF CARRIER USING CATV COAXIAL CABLE)

The IEEE-802 Standard specifies a broadband midsplit Community Antenna Television (CATV) option that uses the same technology found in commercial CATV systems that distribute television signals to private residences. Transmission of digital data over CATV is a relatively recent development but CATV has been around for 20 years and is a very mature and reliable technology. This system operates at 5 or 10 Mbps using Vestigial Side Band Amplitude Modulation (VSB/AM), Manchester encoding, and CSMA/CD on standard 6-MHz TV channel (IEEE-802, Draft B, 1982).

The use of signaling using a carrier and coaxial cables contrasts with baseband which does not employ a carrier, e.g., Ethernet. In baseband signaling the entire bandwidth of the cable is used because square wave (digital) signaling depends on the presence of high-frequency components whereas broadband modulates a carrier, which results in fewer high-frequency components and an attendant conservation of bandwidth.

The advantage of a broadband system is that it is multimedia in nature and, for example, can carry not only multiple data channels but voice and video on the same physical cable by use of frequency division techniques (see Fig. 4). The disadvantages are the costs of the modems that are required to interface digital devices and a somewhat slower signaling rate.

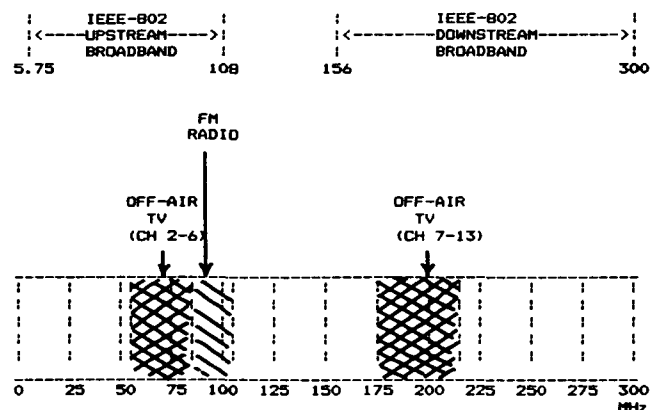


Fig. 4 BROADBAND FREQUENCY SPECTRUM

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The IEEE-802 broadband system is a directional transmission system that employs two different frequency bands on the coaxial cable; the upstream, 5.75-108 MHz, is used for data being transmitted; the downstream, 156-300 MHz, for data being received. A head-end uses an analog translation device (similar to a communications satellite transponder) to translate incoming signals to the outgoing frequency; thus, when a station transmits data to another station it transmits to the head-end in upstream band, the head-end translates this data to the downstream band and sends it back down the cable where it can be received by the intended station.

Because of the high frequencies involved, the delay through the cable is a significant number of bit periods, this means collisions often will not be detected as promptly on a broadband network. In addition, the same delay applies to "carrier sense" when in the "deferring" mode while the sender has a packet to send and is waiting for a free channel. A station may not detect a channel becoming free for over 133 bit times and, even worse, there will be a delay before a station can detect that the channel is busy. This increases the probability of collisions, and mandates a longer "slot time", increasing collision recover time. Also broadband must be carefully tuned to ensure that the signal level is the same at all outlets, where this is not necessary in simpler baseband. Thus, expert design and installation are required; once installed, however, the maintenance is low and the installed cost per outlet is low, if done for an entire area at once (Berman, 1982).

BROADBAND ADVANTAGES AND DISADVANTAGES (Berman, 1982)

BROADBAND ADVANTAGES

- o high aggregate bandwidth
 - as many as 17 std. 6-MHz TV channels,
- capable of carrying up to 10Mbps each
- o mature, std. tran. tech. based on 20 yrs CATV exp.
- o wide geographic coverage, realistic max. dist. from headend is 10 km
- o cable plant may already exist
- o wall taps at under \$100
- o almost unlimited number of outlets

BROADBAND DISADVANTAGES

- o transmission system
 - requires expert design and installation
 - no widely accepted stds. in existence for use with data (modulation tech., spectrum allocation)
- o problems possibly caused by transmission delays in using CSMA/CD in geographically large networks (all data must travel from terminal to headend and back)
 - larger "slot times" required
 - delayed detection of carrier
 - delayed detection of collision
 - max. eff. under heavy load worse than Ethernet
 - higher prob of lockup under very heavy load
- o very limited experience with computer-to-computer multiaccess channels
- o efficient broadband data modems expensive

3.2) TOKEN PASSING

This access technique allows one device at a time to have access rights to the communication channel. When through the device passes the token to another device, thus delay times are deterministic rather than statistical as in contention. In addition, contention schemes are limited in distance for a given data rate and data unit size if collision detection is to work; token passing is not constrained by the communication line length. However, token passing is considerably more complex than contention, not generally available, and is not included in the comparisons in this paper.

3.3) PERFORMANCE CONSIDERATIONS

The maximum throughput between 2 stations on a LAN is usually a small fraction of the trunk capacity. The trunk rate should be used as a measure of maximum aggregate load, because point-to-point throughput is more a function of network-to-host interface design. High level protocols are taxing on host computers and severely limit performance if implemented in host software, therefore, network interface units should implement as much of the protocol as possible without host assistance and should have high bandwidth (Berman, 1982).

4.0) IBM BLOCK-MULTIPLEXER INTERFACES

With the exception of Network Systems Corp. (NSC), none of the LAN vendors currently offers a channel interface to IBM hosts so that signaling rates of 1 Mbps or greater can be obtained. Thus before comparing LAN products we need to spend some time discussing the AUSCOM/IBM channel interface and the IBM Device Attachment Control Unit (DACU) that will be referred to in Table 1.

4.1) THE AUSCOM 8911 IBM CHANNEL INTERFACE

The AUSCOM 8911 enables access to an IBM standard channel interface. To use the 8911 the host must support an IBM channel (or look-alike) with one or more subchannel addresses reserved for this application. The channel can be configured as a block mux, selector, or byte-mux channel.

The 8911 consists of a DEC LSI-11 that resides in the data path between the host channel and the Ethernet Cable. AUSCOM-supplied boards plugged into the QBUS interface the IBM channel, and an Interlan-supplied board (NI 2010) plugged into the QBUS interfaces the Ethernet cable (see Fig. 5).

The software running in the LSI 11 consists of two components: the emulation software and layered software "glued together" by AUSCOM's ARIES operating system.

The emulation software is responsible for sending and receiving control information and data across the host channel. The software can emulate both standard and non standard IBM devices, e.g., tape drive, 3272 local terminal (most popular) or a nonsupported device.

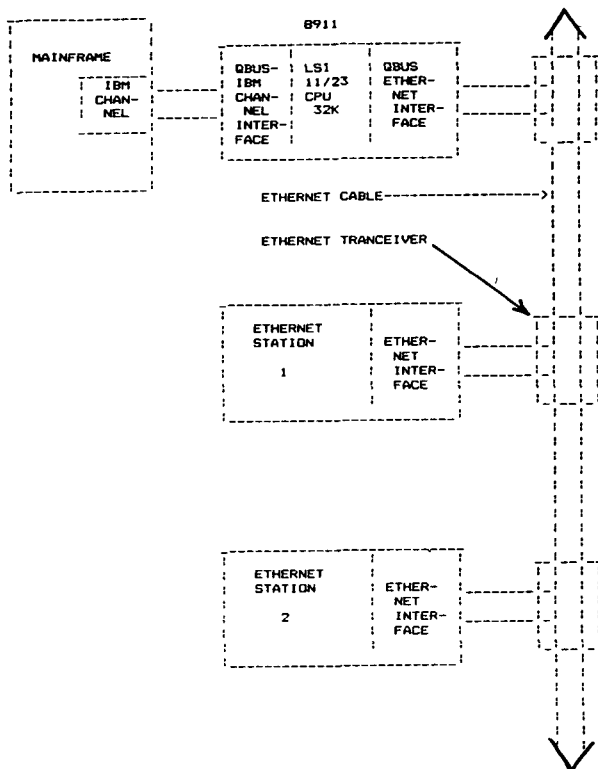


Fig. 5 AUSCOM HARDWARE CONFIGURATION

The layered software is designed to provide error free transmission between the IBM channel and one or more Ethernet stations.

The layered software encompasses the first two layers of the ISO Reference Model and is subdivided by AUSCOM into three components: the Ethernet physical layer, the Internet gateway layer, and a custom stop-and-wait error-recovery layer called MESSAGESYS.

The physical layer consists of I/O drivers for an Interlan NI 2010 QBUS Ethernet communication controller.

The Internet Layer provides IBM to Ethernet addressing.

The MESSAGESYS Layer provides two functions: a.) flow control between IBM and Ethernet stations; b.) error recovery by retransmission using a stop-and-wait protocol. Also under development is a higher speed protocol tentatively called "Blastnet" (Farmer, 1983) which uses a "which-ones packet" and a "bitmap" to acknowledge more than a single packet at a time.

4.2) IBM PERSONAL COMPUTER USED AS A DEVICE ATTACHMENT CONTROL UNIT (DACU)

Interestingly, the IBM Personal Computer has been developed into a product known as the Device Attachment Control Unit (DACU), which allows the IBM block-multiplexer channel on an IBM/370 computer to be interfaced to support: RS 232-C, DEC UNIBUS, the attachment of non-IBM devices. Control programs are executed in the DACU (IBM Personal Computer) to support the requirements for I/O associated with the attached devices.

The DACU provides a UNIBUS interface for the attachment of UNIBUS compatible I/O devices via a connector equivalent to the DEC DD-11C connector block. This interface provides for simulated direct memory access I/O transfers to and from the IBM/370 main storage at speeds of over 1 MByte/s. Actually the transfers are buffered through the DACU storage. Facilities for programmed I/O are also provided. The UNIBUS interface and associated DACU handle device interrupts in a manner that simulates processing in a conventional UNIBUS environment.

The DACU is designed to be compatible with OS/VS2 and VM/CMS.

Significant is the fact that the IBM channel architecture and UNIBUS architecture are incompatible. The IBM channel is always master of the interface, and control units and devices are always slaves; an I/O device can never control the flow of information from processor main storage to itself. On the other hand, with the UNIBUS, any device on the bus (processor or I/O device) can be master once granted bus mastership by the arbitration mechanism.

The DACU functions to solve this architectural incompatibility by serving as a mediator between the architectural differences, i.e., with respect to the IBM channel the DACU is always a slave; with respect to the UNIBUS, the DACU may be master or slave.

Two RS 232-C ports are also provided that operate up to 19.2 Kbps.

The DACU has interesting possibilities for networking IBM machines to DEC machines, as many of the LAN vendors (see Section 5) provide UNIBUS compatible interfaces.

5.0) VENDOR COMPARISONS

The following discussion covers 6 different manufacturers of networking products. The narrative follows Table 1 at the end of this paper with respect to topics discussed. Refer to Fig. 7a for a diagram of the generic baseband system and Fig. 7b for the generic broadband system.

5.1) INTERLAN

Interlan provides microprocessor-based, firmware-driven, Ethernet boards that plug directly into a number of computer busses, as well as an Ethernet Module and Ethernet transceivers; all are manufactured to the "Ethernet, Blue Book" Specification (The Ethernet, 1982). The board has 16K of FIFO memory that will buffer at least 8 received packets and 2K memory for a transmit buffer. All data transfers to the host are via DMA. The Interlan hardware continuously collects network statistics on a non-interference basis.

RANGE/SPEED

Range is 2.5 Km. The Ethernet cable is capable of burst speeds of 10 Mbps. The speed using the Interlan hardware (without operating system), according to an Interlan benchmark, is 2.5-3.0 Mbps point-to-point.

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Due to the fact that only OSI Layers 1 and 2 are in the Interlan hardware, speed with full protocol will be considerable less than this.

NUMBER OF CHANNELS (P-SAPs), MEDIUM, MODULATION TECHNIQUE

Because this employs baseband signaling, only one channel is available that uses the entire Ethernet coaxial cable.

IBM HARDWARE INTERFACE

As there is not presently available from Interlan a FIPS-60 interface to an IBM channel, the AUSCOM 8911 or the DACU as described in Section 4 above would be a candidate for connecting an IBM host within a LAN.

DEC HARDWARE INTERFACES

Unibus, QBUS (see discussion of AUSCOM above).

DRIVERS

Interlan provides driver software for UNIX V7, VAX/VMS, PDP11/RX-11M, and LSI-11/RX-11M and RT-11 V 4.0. The VMS driver can utilize the VMS's "buffered data paths" for improved performance using the Unibus.

No driver exists for the IBM; however, Century Computing (Kurtz, Miller, 1983) have software (VAX Interface Unit, VIU) that links the IBM System Network Architecture (SNA) with a VAX via an IBM 3705 communications unit. Software to link VIU to DECnet would have to be developed, however. This solution is also limited by the speed of the IBM 3705.

TYPE OF SERVICE

Connectionless (Datagram) service -- Packet address recognition, carrier deferring and automatic backoff, and retransmission on collision detection are performed by the Interlan hardware.

ISO LAYERS

Layers 1 and 2 are contained in the Interlan hardware. On the DEC side, all higher layers would be handled by DECnet. On the IBM side, if SNA were gatewayed to DECnet SNA would handle the higher layers, other wise the customer would need to develop the higher layers. It is probably best to gateway from one computer manufacturer's networking product to another rather than develop your own, unless there are some very compelling reasons.

Interlan also sells a product called Internet Transport Protocols (ITP) based on the Xerox specifications. These provide the architectural foundation for Xerox's distributed systems. With ITP, VAX/VMS and RSX-11M systems can achieve task-to-task communications with most of the Ethernet-compatible systems manufactured by Xerox and other ITP-compatible vendors. Both connectionless and connection services are supported as well as routing.

5.2) 3COM

3COM manufactures Ethernet "Blue Book" compatible system components. They began production in December 1980 and have delivered over 200 Bus Interface Units (BIUs). They also manufacture transceivers and cables. The orientation of the company is toward selling components rather than complete systems.

RANGE/SPEED

Cable lengths of up to 1 km without repeaters and up to 2.5 km with repeaters can be installed. The Ethernet cable is capable of burst speeds of up to 10 Mbps; 3COM benchmarks between DEC machines have been measured at speeds of 1.5 Mbps using the 3COM hardware.

NUMBER OF CHANNELS (P-SAPs), MEDIUM, MODULATION TECHNIQUE

Because this employs baseband signaling, using CSMA/CD, only one channel is available that uses the entire Ethernet cable. It should be noted that although the BIU detects collisions and errors, host intervention is necessary to recover from a collision.

IBM HARDWARE INTERFACE

As there is not presently available an interface to the IBM block multiplexer channel from 3COM, the AUSCOM 8911 or the DACU both described in Section 4 would be candidates for connection to the IBM host within a LAN.

DEC HARDWARE INTERFACE

3COM offers interfaces to the UNIBUS and QBUS. 3COM uses an interfacing scheme where each board has dual ported memory, accessible by both the Ethernet controller or the UNIBUS (or QBUS). Also, the Ethernet interface utilizes multiple "state machines", based on programmable array logic chips, instead of a single thread interrupt-driven microcomputer, in order to achieve rapid response times.

DRIVERS

3COM supplies supported drivers for the UNIBUS under DEC VAX/VMS, RT-11, and RSX-11M. No driver exists for the IBM, however, Century Computing (Kurtz, Miller, 1983) have software (VAX Interface Unit, VIU) that links IBM System Network Architecture (SNA) with a VAX via IBM 3705 communication unit. Software to link VIU to DECnet would have to be developed, however. This solution is limited by the speed of the IBM 3705.

TYPE OF SERVICE

Connectionless (Datagram) service is provided.

ISO LAYERS

Layers 1 and 2 are provided in the controllers. 3COM also markets UNET, a version of DARPA's TCP/IP transport and internet protocol that runs under UNIX and performs Layers 2.5 through 5 functions.

5.3) NETWORK SYSTEMS CORP. (NSC) - HYPERCHANNEL

Hyperchannel, available in 1977, was one of the first high-performance host-to-host or host-to-peripheral digital data links on the market. In June of 1982 there were 400 units installed at 160 different sites.

RANGE/SPEED

Raw speed of 50 Mbps can be obtained if the largest coaxial cable (1.1" OD) is used. Speed with protocol measured by NSC is in the range of 4-5 Mbps. Range, using 1.1" OD cable and 10 or less adapters, is 1.5 km without repeaters, 3 km with repeaters. NSC manufactures a Link Adapter (A710) that will provide unlimited extension of the network via private and public communications and communications satellite.

NUMBER OF CHANNELS (P-SAPs), MEDIUM, MODULATION TECHNIQUE

Because this is a baseband implementation, only one channel (P-SAP) is provided over a single coaxial cable (trunk) that can range in size from 0.27" to 1.1" OD depending on distance; however, a Hyperchannel adapter can support up to 4 trunks (one at a time). The larger cable is aluminum clad, semirigid and the bending radius could be a problem in some installations. Connectors/hardware for turning corners are available but total loss through the cable cannot exceed 20db.

NSC uses a variant of CSMA/CD Media Access Control which is not covered by the IEEE 802 Family of Standards. NSC calls it collision avoidance. This Media Access Control is used with two overall priorities and subpriorities based on the adapter address. The CSMA/CD backoff interval is also based on the adapters address, so some adapters will always have priority over others. The network protocol is a variant of IBM SDLC which requires that the destination unit respond to the source after every message, so all transfers are interlocked, block by block (Thornton, 1975).

Adapters cannot be connected to the cable without the knowledge of the entire network configuration so that the appropriate backoff interval can be entered into the adapter.

IBM HARDWARE INTERFACES

NSC manufactures a IBM Block Mux Channel interface (A222 Adapter).

DEC HARDWARE INTERFACES

The A400 adapter is used to interface UNIBUS (via PI13 card plugged into the backplane), MASSBUS (via a PI11 plugged into the backplane) and QBUS (PI 12, via a DRV-11) interfaces. The A400 will service up to 4 co-located DEC computers within 50 ft of the A400. However, only one host can transfer data through the adapter at a time.

DRIVERS

Network Access Method (NETEX) for host to host communication has been available from NSC since the Fall of 1982. NETEX contains drivers for IBM MVS, VAX VMS and RSX 11/M.

TYPE OF SERVICE

Connection service is provided by NETEX. CRC checking and retransmission are located in the Data Link Layer in the NSC Adapter. Flow control and lost or out of order packet situations are handled by NETEX.

ISO LAYERS

NETEX has been designed to adhere to the ISO Reference Model (see Fig. 6) and encompasses Layers 3 through 5. NETEX is available for IBM MVS, VAX/VMS, and RSX11/M.

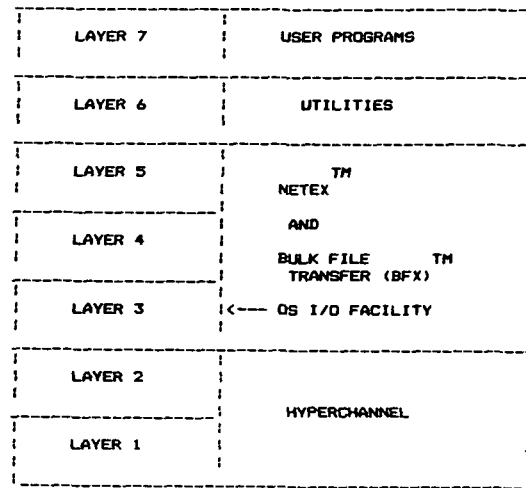


Fig. 6 NETEX AND THE ISO REFERENCE MODEL

The following is an overview of the MACROS offered by NETEX.

- o SOFFER - Offer the availability of an application on a given host by logical name.
- o SCONNECT- Connect to a specific offer request on a specific host.
- o SCONFIRM- Confirm a connection: applications may exchange data.
- o SDISCONNECT- Disconnect two applications.
- o SWRITE- Sends data to the connected application.
- o SREAD- Waits for and accepts data from a connected application.
- o SSTATISTICS- Gathers raw session activity statistics.

There is also available an associated NETEX product called Bulk File Transfer (BFX) for the transfer of bulk data in conjunction with NETEX.

5.4) UNGERMANN-BASS(U-B) INC.NET/ONE SYSTEM

Net/One supports both baseband on Ethernet cable and mid-split broadband on CATV cable, both using CSMA/CD, and adhering to the IEEE-802 Draft Standard. In addition several different types of interfaces are supported (RS 232, IEEE-488, 8, 16 and 32 bit parallel some with DMA). The Net/One baseband and broadband products are identical except for the Physical Layer logic and modem/transceiver modules in the Network Interface Units (NIUs) and in the Network Configuration Facility (NCF). The NCF is a Z80 microprocessor-based product that runs the CP/M operating system and is used to configure the network and to download the software to the NIUs and to run diagnostics. This feature is especially useful when software maintenance needs to be applied to the NIUs. However, it also constitutes a single point of failure for activating the network. The NIUs are also Z80 based and are user programmable.

Net/One can be operated in both the Connectionless (Datagram) mode and the Connection (Virtual Circuit) mode. In the Connection mode, speeds are limited to 19.2 Kbps; and this mode would be used, for example, to connect terminals to a host. In the Connectionless mode, the higher speeds are available for host-to-host transfers. U-B has announced a 16-bit NIU for later in 1983.

RANGE/SPEED

Range for the baseband and broadband systems are 2.5 Km and 16 Km respectively. Raw signaling speeds are 10 Mbps for baseband and 5 Mbps for broadband, with a U-B benchmark showing end-to-end rates of 1.5-2.0 Mbps with a very basic driver using VAXes; end-to-end rates with full protocol are probably in the range of 900 Kbps.

NUMBER OF CHANNELS (P-SAPs), MEDIUM, MODULATION TECHNIQUE

Net/One baseband, using Ethernet cable, supports the usual single channel, however Net/One broadband (like Sytek's LN-40, see Section 5.5) supports five 6 MHz TV channels (P-SAPs). However, unlike LN-40, these are not software switchable, but require hardware to be physically moved. The modulation technique for broadband is Vestigial Side Band (VSB).

IBM HARDWARE INTERFACE

No IBM channel interface for high speed transfer is currently available. However, with Net/One operated in the Connection mode (up to 19.2 Kbps) the RS 232 port can be interfaced to an IBM 3705 communication controller. A high speed possibility may be the AUSCOM channel interface or the DACU previously discussed; however, U-B has no announced plans to support these devices.

DEC HARDWARE INTERFACE

U-B supports a UNIBUS interface that uses a DR11-W or DR11-B for 32 bit transfers via DMA.

DRIVERS

U-B offers to supply a prototype driver for the DR11 developed by one of its customers.

TYPE OF SERVICE

CSMA/CD is used in both the baseband and broadband implementations. The following services are provided:

Connection (Virtual Circuit) service at up to 19.2 Kbps.

Connectionless (Datagram) service at the higher speeds.

ISO LAYERS

For the Connection Service, Layers 1 through 5 are provided in the NIUs.

For the Connectionless Service, Layers 1 and 2 are provided in the NIUs. All higher Layers will have to be provided by the customer, probably residing in the hosts, although it is possible for the customer to program the NIU.

5.5) SYTEK LOCAL NET 40 (LN-40)

The Sytek Local Net 40 is a broadband, mid-split system that uses standard CATV cable. Sytek is affiliated with General Instrument Corp., the world's largest supplier of CATV equipment. Sytek also markets a Local Net 20 (LN-20) product which is a 128 Kbps terminal-to-host LAN, operational in a large number of installations. Unfortunately, Sytek has encountered performance problems with the current implementation of Local Net 40 which was in beta test in 1982. An IBM channel interface, originally scheduled for March 1983, is now in the queue behind the solution to these problems (Koller, 1983). Also planned are a Network Control Center which will provide performance monitoring and traffic analysis for the network and support for data encryption (DES). Gateways to X.25 and TCP/IP networks are also planned.

RANGE/SPEED

Broadband has a range of 10 Km (5 Km radius) and LN-40 was to have a raw signaling speed of 2 Mbps; however, beta testing has revealed speeds of 300 Kbps (Koller, 1983), and this of course, is where the problem lies.

NUMBER OF CHANNELS (P-SAPs), MEDIUM, MODULATION TECHNIQUE

Five dynamically software selectable P-SAPs are supported, i.e., separate 6 MHz TV channels over standard CATV cable using CSMA/CD. LN-40 uses frequency agile modems (FAMs) using frequency shift keying (FSK) modulation. Modems do not conform to the IEEE-802 Draft Standard.

IBM HARDWARE INTERFACES

No IBM channel interface is currently available; however, one is planned after the previously mentioned performance problems are solved. Another possibility is the AUSCOM interface or the DACU previously discussed in Section 4.

DEC HARDWARE INTERFACES

The UNIBUS interface was in beta test in 1982.

DRIVERS

Along with the UNIBUS interface, Sytek plans to supply a VAX/VMS driver and an RSX-11M driver for the PDP series.

TYPE OF SERVICE

LN-40 uses 16-bit microprocessors called the Packet Communications Units (PCUs) that implement OSI Reference Model Layers 1 through 4 using the CSMA/CD technique to stochastically share channels. Implementing Layers 1 through 4 in the PCU should considerably off-load the host and result in improvements in the end-to-end transfer rates when the previously mentioned performance problems are solved.

ISO LAYERS

Layers 1 through 4 are implemented in the PCU. Also high-level software for VAX/VMS and PDP-11/RSX-11M is to be provided: OPEN, READ, WRITE, CLOSE macros, for example.

5.6) CONTEL CONTELNET

CONTEL, a subsidiary of Continental Telecom, Inc., markets a networking product that uses either baseband (700 series) or mid-split broadband (800 series) technology that is based on the IEEE-802 Draft Standard. The Bus Interface Units (BIUs) use Z80s with a Multibus backplane running under the proprietary TICOS operating system. Configurations can be converted from baseband to broadband and from 2 Mbps to 10Mbps by substitution of proper boards. Each BIU controls four serial RS 232-C ports and a parallel port for host communications. The BIUs are down-line loaded from the Network Control Center (NCC) and can up-line dump as well. CONTEL operates as a custom applications house (Stack, 1983).

RANGE/SPEED

Range is 3 km and 16 km for baseband and broadband, respectively, with raw signaling speeds of 2-10 Mbps. End-to-end transfer rates with protocols were not available.

NUMBER OF CHANNELS (P-SAPs), MEDIUM, MODULATION TECHNIQUE

CONTEL baseband, using Ethernet cable, supports the usual single channel; however, CONTEL broadband (like Sytek's LN-40) supports five 6 MHz TV channels (P-SAPs). However, unlike LN-40, these are not software switchable, but require factory setup. The modulation technique for broadband is FSK.

IBM HARDWARE INTERFACE

No IBM channel interface for high speed transfer is currently available. However, with CONTELNET operated in the Connection mode (up to 19.2 Kbps), an RS 232-C port can be interfaced to an IBM 3705 communications controller. Another possibility may be the AUSCOM or DACU channel interface previously discussed; however, CONTEL has no announced plans to support this device.

DEC HARDWARE INTERFACE

A prototype QBUS interface has been developed.

DRIVERS

No drivers for IBM or DEC are currently offered.

TYPE OF SERVICE

CSMA/CD is used in both the baseband and broadband implementations. The following services are provided:

Connection (Virtual Circuit) service at up to 19.2 Kbps.

Connectionless (Datagram) service at the higher speeds.

ISO LAYERS

Layers 1 and 2 are in the BIUs, higher Layers are not presently provided.

VENDORS ADDRESSES

AUSCOM Inc. 2007 Kramer Lane, Suite 102, Austin, Texas 78758.

3COM, 1390 Shorebird Way, Mountain View, California 94043.

ConTel Information Systems, Information Products Division, 130 Steamboat Road, Great Neck, New York, New York 11024.

Interlan, 160 Turnpike Road, Chelmsford, Massachusetts 01824.

Network System Corporation, 7600 Boone Avenue North, Brooklyn Park, Minnesota 55428.

SYTEK, 1153 Bordeaux Drive, Sunnyvale, California 94086.

Ungermann-Bass, One Burlington Woods Drive, Burlington, Massachusetts 01803.

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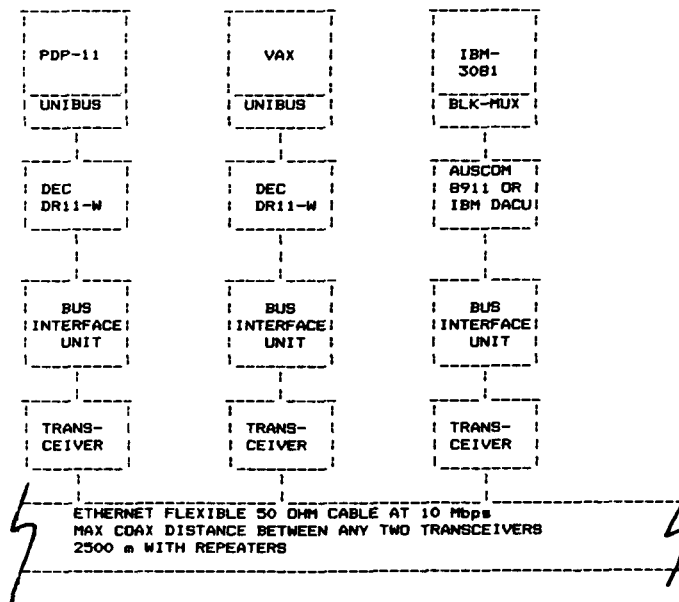


Fig. 7a GENERIC BASEBAND SYSTEM

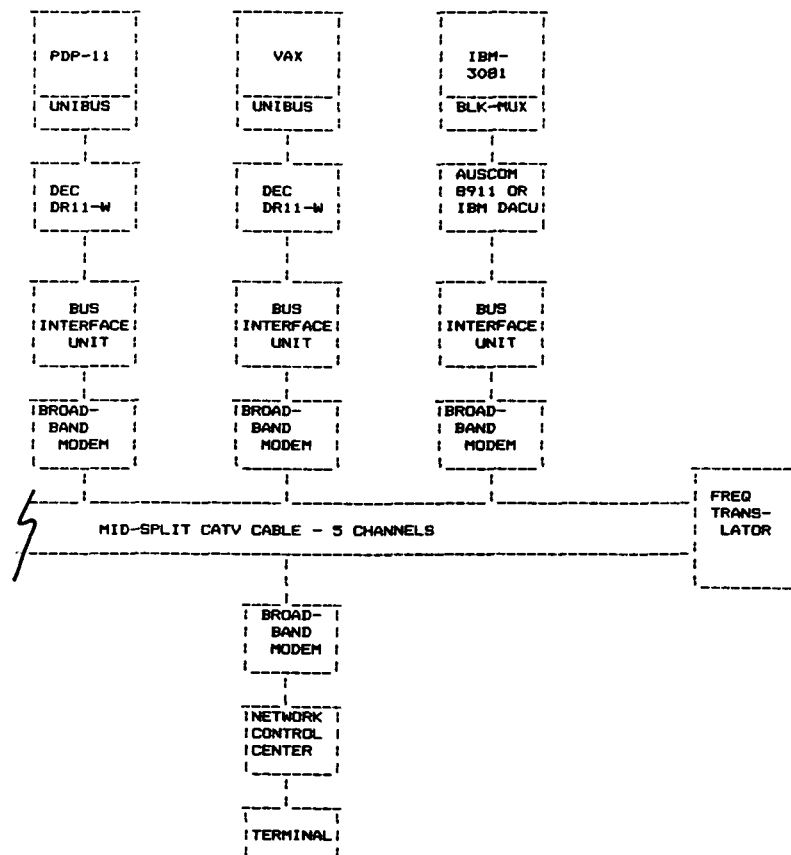


Fig. 7b GENERIC BROADBAND SYSTEM

TABLE 1

	INTERLAN BASEBAND	3 COM BASEBAND	NSC BASEBAND	U-B BASEBAND	U-B BROADBAND	SYTEK BROADBAND	CONTEL BROADBAND	CONTEL BASEBAND
PRODUCT	NI 1010A (UNIBUS) NI 2010A (QBUS)	3C300	HYPERCHAN	NET/ONE	NET/ONE	LN-40 ⁽³⁾	CONTELNET (802)	(702)
RANGE	2.5 KM	2.5 KM	1.0 KM ⁽⁴⁾ 3.0 KM	2.5 KM	16 KM	10 KM	3 KM	16 KM
RAW SPEED	10 MBS	10 MBPS	50 MBPS	10 MBPS	5 MBPS	2 MPS	2 MBPS	10 MBPS
SPEED WITH PROTOCOL	2.5-3.0 MBPS	1.5 MBPS	4-5 MBPS	1.5-20 MBPS	1.5-20 MBPS	500 KBPS	?	?
NUMBER OF CHANNELS (P-SAPS)	1	1	1	1	5 (6 MHz TV)	5 (6 MHz TV)	5 (6 MHz TV)	1
MEDIUM	ETHERNET COAX CABLE	ETHERNET COAX CABLE	0.27"-1" SEMI- RIGID COAX CABLE	ETHERNET COAX CABLE	CATV	CATV	CATV	ETHERNET COAX CABLE
MODULATION TECHNIQUE	BASEBAND	BASEBAND	BASEBAND	BASEBAND	VSB/AM MID-SPLIT	FSK MID-SPLIT	FSK MID-SPLIT	BASEBAND
IBM HDW INTERFACE	AUSCOM 8911 ⁽²⁾ OR DACU	AUSCOM 8911 OR DACU	HIGH SPEED IBM INTERFACE BLOCK MUX (A222)	AUSCOM 8911 OR DACU	AUSCOM 8911 OR DACU	AUSCOM 8911 OR DACU	AUSCOM 8911 OR DACU	AUSCOM 8911 OR DACU
VMS	UNIBUS	UNIBUS	UNIBUS (PI13)	UNIBUS (DR11W)	UNIBUS (DR11W)	UNIBUS BETA TEST	NONE	NONE
RSX-11M	UNIBUS	UNIBUS	UNIBUS (PI13)	UNIBUS (DR11W)	UNIBUS (DR11W)	UNIBUS BETA TEST	NONE	NONE
RSX-11M RT-11	QBUS	QBUS	QBUS DRV11B TO A PI 12	NO	NO	NO	PROTOTYPE QBUS	PROTOTYPE QBUS
IBM MVS DRIVER	NO	NO	YES, NETEX	NO	NO	NO	NONE	NONE
VAX/VMS DRIVER	YES UNIBUS	YES UNIBUS	YES, NETEX UNIBUS	YES UNIBUS	YES UNIBUS	YES UNIBUS ?	NONE	NONE
PDP 11/RSX11M DRIVER	YES UNIBUS	YES UNIBUS	YES, NETEX UNIBUS	YES, PROTO- TYPE FOR DR11 FROM CUSTOMER	YES, PROTO- TYPE FOR DR11 FROM CUSTOMER	YES?	NONE	NONE
LSI 11/RT11 DRIVER	RT-11V4	?	NO	NO	NO	?	NONE	NONE
TYPE OF SERVICE	DATAGRAM	DATAGRAM		DATAGRAM ⁽⁶⁾ OR CONNECTION (AT 19.2)	DATAGRAM OR CONNECTION (AT 19.2)	DATAGRAM OR CONNECTION	POSSIBLE DATAGRAM OR CONNECTION	POSSIBLE DATAGRAM OR CONNECTION

TABLE 1 (cont.)

	INTERLAN BASEBAND	3 COM BASEBAND	NSC BASEBAND	U-B BASEBAND	U-B BROADBAND	SYTEK BROADBAND	CONTEL BROADBAND	CONTEL BASEBAND
IEEE 802 LLC MAC & PHYSICAL LAYER	CSMA/CD ETHERNET CABLE	CSMA/CD (7) ETHERNET CABLE	COAX CABLE CSMA/CD VARIANT (4)	CSMA/CD ETHERNET CABLE	CSMA/CD CATV CABLE	CSMA/CD CATV CABLE	CSMA/CD CATV CABLE	CSMA/CD ETHERNET CABLE
	IN NI1010 BOARD	IN 3C300 BOARD (BIU)	IN ADAPTER A400, A222	IN NIU-280 16-BIT SUMMER 83 (5)	IN 16 BIT PCU		IN BIU	IN BIU
NETWORK	NONE	NONE	NETEX IN HOST	FOR CONNECTION ONLY (5)	IN PCU		IN BIU	IN BIU
	DEC NET ON ETHERNET	TCP/IP UNDER UNIX	NETEX IN HOST	FOR CONNECTION ONLY (5)	IN PCU		IN BIU	IN BIU
TRANSPORT	NONE	NONE	NETEX IN HOST	FOR CONNECTION ONLY (5)	IN PCU		IN BIU WITH X.25	IN BIU WITH X.25
	DEC NET ON ETHERNET	TCP/IP UNDER UNIX	NETEX IN HOST	FOR CONNECTION ONLY (5)	IN PUC		IN BIU WITH X.25	IN BIU WITH X.25
SESSION	NONE	NONE	NETEX IN HOST	NONE	NONE	NONE	NONE	NONE
	DEC NET ON ETHERNET	TCP/IP UNDER UNIX	NETEX IN HOST	NONE	NONE	NONE	NONE	NONE

(1) HYPERCHANNEL DOES NOT FIT ANY OF THE CURRENT IEEE-802 PROPOSED STANDS.

(2) IBM SELECTOR, BYTE MUX OR BLOCK MUX CHANNEL VIA STD BUS & TAG CABLES.

(3) REDESIGN OF MODEL 40 UNIT IS UNDERWAY DUE TO A PERFORMANCE PROBLEM - IBM INTERFACE IS QUEUED UP BEHIND THIS REDESIGN.

(4) 3KM WITH REPEATER, 1.5 KM WITHOUT; LINK ADAPTER (A710) WILL EXTEND INDEFINITELY, E.G., SATELLITE ETC.

(5) MOTOROLA 68000.

(6) DATAGRAM-LAYER 4 RESPONSIBLE FOR ENSURING DATA ARE GETTING THROUGH CORRECTLY.
CONNECTION-LAYER 2 RESPONSIBLE FOR ENSURING DATA ARE GETTING THROUGH CORRECTLY.

(7) HOST INTERVENTION REQUIRED TO RECOVER FROM A COLLISION

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